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ABSTRACT

This study assessed whether there was any relationship between scores on the mathematics section of the Pre-Professional Skills Tests (PPST) and selected possible predictors of performance for 118 students at Harding University in Searcy (Arkansas) who took the PPST between January 1, and October 1, 1989. Focus was on providing information that could help universities identify high-risk education majors who may need special assistance. Possible predictor variables were: (1) scores on the American College Testing (ACT) Program tests; (2) sex; (3) race; (4) academic major; (5) grade point average (GPA); (6) age; (7) semester grades in Mathematics 115; and (8) previous PPST scores. Significant correlations were found between PPST mathematics scores and ACT composite scores, ACT mathematics scores, ACT English scores, ACT social studies scores, ACT natural science scores, GPA, and semester grades in Mathematics 115. The failing rate for education majors (30.4%) was significantly higher than that for other majors. No significant differences were found for age and sex. Failing rates for race were not computed because of a lack of non-Caucasian students. For those who repeated the examination, there was no significant difference between test and retest means. A regression equation was developed for the prediction of PPST mathematics scores at Harding University from ACT composite and mathematics scores. Suggestions for further research include a study of using an ACT cut-off score to exempt students from the PPST mathematics examination and a study of intervention programs for students at risk of failing the PPST mathematics examination. (SLD)

PREDICTORS OF PERFORMANCE ON THE MATHEMATICS TEST OF THE PRE-PROFESSIONAL SKILLS TESTS

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Abstract

The purpose of this study was to determine whether there was any relationship between PPST Mathematics scores and ACT scores, sex, race, major, GPA, age, Math 115 semester grades, and previous PPST scores for a group of 118 Harding University (Searcy, AR) students who took the PPST between January and October of 1989.

Significant ($p < .001$) correlations were found between PPST Math and ACT Composite (.84), ACT Math (.80), ACT English (.58), ACT Social Studies (.64), ACT Natural Science (.73), GPA (.53), and Math 115 semester grades (.60).

Elementary education majors had a failing rate of 30.4% which was significantly ($p < .01$) higher than the failing rate of 11.1% for other majors. No significant difference was found for age or sex. Failing rates for race were not computed because of a lack of non-Caucasian subjects.

For those who repeated the exam, there was no significant difference between the mean of the first exams and the mean of the retakes.

A regression equation was developed for prediction of PPST Math scores at Harding from ACT Composite and ACT Mathematics scores:

PPST Math = .9029 (ACT C) + .3706 (ACT M) + 151.7171.

Suggestions for further research include a study of the possibility of an ACT cut-off score to be used to exempt qualified students from the PPST Math exam and a study of the possibility of intervention programs for students who are at risk of failing the PPST Mathematics exam.

Since January 1, 1989, Arkansas students have been required to pass the Pre-Professional Skills Tests (PPST) before admission to a teacher education program. One of these tests is devoted to basic skills in mathematics. Educators have been considering ways to predict success on the PPST since the tests were first used in 1983. This study investigated possible factors for prediction of performance on the Mathematics Test of the PPST.

Review of Related Literature

Previous research has shown several factors to be related to PPST success.

American College Test (ACT)

Among the most frequently researched factors are ACT scores (Aksamit, Mitchell, & Pozebl, 1987; Heard, 1988; Nance & Kinnison, 1988; Sibert, 1989; Stoker & Tarrab, 1985). The ACT exam is usually taken during the senior year of high school or after high school graduation. It is designed to measure ability to do college-level work. Subtests are given in English, mathematics, social studies, and natural science.

Stoker and Tarrab (1985), in a study of 129 West Texas State University students, found a correlation of .70 between PPST Mathematics scores and ACT Mathematics

scores. The correlation between PPST Mathematics scores and ACT Composite scores was .69. They suggested that the use of the PPST may be unnecessary if repeated studies show high correlations between ACT scores and PPST scores.

Askamit et al. (1987) collected data from 537 education majors in a large, midwestern, public university. They found a correlation of .71 between PPST Mathematics and ACT Composite and a correlation of .76 between PPST Mathematics and ACT Mathematics. Their recommendation was that "in order to save time, energy, and money" (p. 52) ACT cut scores might be adopted which would exempt certain students from the PPST.

Heard and Ayers (1988) found a correlation of .80 between PPST Mathematics and ACT Mathematics and a correlation of .78 between PPST Mathematics and ACT Composite in their study of 202 students at the Tennessee Technological University. They developed a regression equation for prediction of scores on the PPST Mathematics exam:

PPST Math = 165.08 + 0.06 (ACT Math) + 0.48 (ACT Comp) (p. 199). They also suggested that there may not be a need for the use of the PPST when ACT scores are available.

Sibert (1989), in a study of 615 graduates from two schools in Tennessee, found a correlation between PPST Mathematics and ACT Mathematics of .70; PPST Mathematics and ACT Social Studies, .42; PPST Mathematics and ACT Natural Science, .59; PPST Mathematics and ACT English, .39; and PPST Mathematics and ACT Composite, .66. (For all of these correlations $p < .01$.)

Nance and Kinnison (1988) studied 188 education majors in Texas. They found correlations of .76 between PPST Mathematics and ACT Composite; .56 between PPST Mathematics and ACT English; and .72 between PPST Mathematics and ACT Mathematics.

These studies of the relationship between PPST Mathematics scores and ACT scores consistently showed moderately strong correlations between the two.

Scholastic Aptitude Test (SAT)

Bethel, Connelly, de Hart, Armant, and Hunsucker-Evans (1986) analyzed data from more than 400 college students from the University of Texas at Austin and St. Edward's University and Concordia Lutheran College in Austin. They found the SAT Mathematics score to be the strongest single predictor of the PPST Mathematics score. The most efficient prediction of PPST

Mathematics scores came from SAT Writing combined with grade point average (GPA) and SAT Reading.

Sex

Goodison (1985) reported results from a study using scores from all PPST first-time test-takers in the nation from February, 1983 to December, 1984. Using criteria of two states as an example, 82% of the males and 73% of the females met the required score for program entry. The mean score for the males was 178 while the mean score for the females was 175. Goodison stated, "As a group male test-takers score higher than females in Mathematics" (p. 12). There was no discussion as to whether or not these findings were statistically significant.

Bethel et al. (1986) also found that "males tended to have a slightly higher passing rate than females on the [PPST] 'Mathematics test'" (p. 8)--95.3% of the males and 86.9% of the females passed. They stated that this difference was not statistically significant (chi square).

Nance and Kinnison (1988) found no significant statistical differences between males and females on the PPST Mathematics Test.

Race

Bethel et al. (1986) reported that on the PPST Mathematics examination "white students had a 91.8% passing rate, Mexican-Americans a 75.6% passing rate, and Blacks a 69.2% passing rate. . . . Failing rates for Blacks and Mexican-Americans were significantly ($p < .001$) greater than for Whites in Mathematics" (p. 12).

Goodison's (1985) data gives 84% of Whites passing the Mathematics section of the PPST, 35% of Blacks, 46% of Mexican-Americans, and 43% of other Hispanics.

Major

Goodison (1985) reported passing rates on the PPST Mathematics examination for various majors: humanities, 83%; natural science, 91%; social science, 81%; elementary education, 72%; practical arts and sciences, 77%; business, 77%; and education-general, 71%.

Bethel et al. (1986) found that elementary education majors had a failing rate of 15.8% on the PPST Mathematics Test while other majors ranged from 0% (math and science) to 25% (home economics). If home economics, which had only four subjects, were eliminated, the next highest rate would be 13.6% for fine arts and physical education. When elementary

majors were compared to others, the failing rate "approached" (p. 26) significance (chi-square, $p = .058$).

Nance and Kinnison (1988) reported a mean on the PPST Mathematics Test of 180.53 for those planning to teach on the secondary level. This was significantly higher ($p < .05$) than the mean of 177.29 for elementary majors.

Grade Point Average

Bethel et al. divided their subjects into two groups: those with GPAs of 2.5 or higher ($n = 237$) and those with GPAs below 2.5 ($n = 82$). In their study 92.4% of the students with the higher GPAs passed the PPST Mathematics Test and 7.6% of these students failed. Of the students with the lower GPAs, 87.8% passed and 12.2% failed. (These percentages were not given in the study but were calculated for this literature study.)

Askamit et al. (1987) found a correlation of .37 between PPST Mathematics and college GPA.

Nance and Kinnison (1988) found a Pearson correlation ($p < .05$) of .33 between Math GPA (based on six hours of general education requirements) and the PPST Mathematics Test. English GPA (based on 12 hours of general education English) and the PPST Mathematics

Test had a correlation of .32. Education GPA (based on education foundations and methods classes) and the PPST Mathematics Test had a correlation of .54.

Sibert (1989) found a correlation of .38 ($p < .01$) between final, overall GPA and the Mathematics PPST.

Repeaters

Goodison (1985) reported that about one-third of repeat PPST test takers in mathematics made no improvement. Almost 40% of the repeaters gained one to four points. Less than four percent improved by 10 points or more.

Pre-Basic Math Skills Test

The Pre-Basic Math Skills Test, developed by Richard Burns, is used by several colleges in Texas to screen their pre-education majors. "An internal validations study of UTEP [University of Texas at El Paso] students who took both the reading and math screening tests and the PPST indicated that the screening tests predicted passing the PPST with approximately 95% accuracy" (Salinger, 1986, p. 7).

Additional Factors

The literature included other factors possibly related to PPST scores: high school size, ethnicity of the high school, amount of preparation for the PPST,

age, and high school rank (Askamit et al., 1987; Bethel et al., 1986).

Although Salinger and Burns (1985) and Oppenheim (1985) gave nc statistical evidence for their statements, they stressed that the PPST Mathematics examination requires reading skills. Salinger and Burns (1985) stated that "the math test presents 40 'word problems' that also require technical math reading skills. . . . Students whose reading speeds are slow or who are inexperienced in tasks requiring rapid reading and comprehension encounter difficulty finishing the test" (p. 236).

Oppenheim reported a substantial correlation (.74) between the PPST Reading and Mathematics Tests. He suggested that this may be because "the Mathematics Test itself requires considerable reading ability" (p. 1188).

The Problem

Statement of the Problem

The purpose of this study was to determine whether there is any relationship between PPST Mathematics scores of Harding University education students and the students' ACT scores, sex, race, major, GPA, age, Math 115 semester grades, and previous PPST scores. A regression equation for use in predicting performance

by Harding Students on the PPST was developed based on the relationships that were found.

Significance of the Problem

This information could help Harding to identify "high-risk" education students who may need special help. Information from this study might also be used to help other universities in Arkansas or in one of the nine other states which require the PPST in their teacher education programs to develop intervention programs for students at risk.

Hypotheses

1. There is no relationship between scores on the PPST Mathematics exam and the ACT Composite scores.

2. There is no relationship between scores on the PPST Mathematics exam and ACT Mathematics scores.

3. There is no relationship between scores on the PPST Mathematics exam and ACT English scores.

4. There is no relationship between scores on the PPST Mathematics exam and ACT Social Studies scores.

5. There is no relationship between scores on the PPST Mathematics exam and ACT Natural Science scores.

6. There is no relationship between scores on the PPST Mathematics exam and the sex of those taking the exam.

7. There is no relationship between scores on the PPST Mathematics exam and the race of those taking the exam.

8. There is no relationship between scores on the PPST Mathematics exam and the major of those taking the exam.

9. There is no relationship between scores on the PPST Mathematics exam and GPA of those taking the exam.

10. There is no relationship between scores on the PPST Mathematics exam and age of those taking the exam.

11. There is no relationship between scores on the PPST Mathematics exam and Mathematics 115 semester grades.

12. There is no relationship between scores on the PPST Mathematics exam and prior scores on the exam.

Definition of Terms

Mathematics 115 refers to a freshman mathematics course at Harding University, Basic Mathematics for Elementary Teachers.

GPA refers to a subject's cumulative college grade point average based on a 4.00 scale.

Limitations of the Study

This study will only consider Harding University students who took the PPST between January 1, 1989, and October 1, 1989.

It should be noted that majors declared by university students in their freshman or sophomore years may be changed by the end of their college careers.

Methodology

Subjects

The sample for this study was the 118 Harding University students who took the PPST after cut-off scores in Arkansas went into effect on January 1, 1989, and before October 1, 1989. Thirty-two of these students were from Arkansas; the remainder were from 25 other states.

Research Design

The data for this study were obtained from the Testing Office and the Registrar's Office at Harding University. The following information was obtained for each student: PPST scores, PPST test dates, ACT scores (subtests and composite), sex, race, major, GPA, birthdate, home state, and Mathematics 115 semester grade.

Pearson product moment correlations were found between PPST Mathematics scores and ACT Mathematics, ACT English, ACT Social Studies, ACT Natural Science, and ACT Composite. Spearman's rho was found between PPST Mathematics scores and GPA and Mathematics 115 semester grades.

Hypotheses for sex, race, major, and age were tested with chi-square. Percentages passing were calculated for these factors.

A t-test was used to compare previous PPST Mathematics scores with current ones.

Measures

The PPST Mathematics Test consists of 40 multiple-choice items which "represent the kind of mathematics that might be met in any college course, not just in mathematics courses" (The PPST Guide, 1986, p. 101).

The test "is intended to assess examinees' mathematical competencies including skills acquired from having studied mathematics from elementary through secondary school" (PPST Bulletin of Information, 1988-89, p. 16). Test scores range from 150 to 190. For entrance into a teacher education program in the state of Arkansas the cut-off score for Mathematics is 169.

The examination is organized around six categories: (a) number sense, (b) ability to use numbers to quantify thinking, (c) ability to recognize and use mathematical relationships, (d) understanding the mathematical basis of measurement, (e) ability to reason deductively, and (f) ability to interpret graphic, symbolic, and verbal material (The PPST Guide, 1986, p. 101).

The internal reliability of the Mathematics Test, as calculated by the Kuder-Richardson formula, is .877. The standard error of measurement is 2.6 (Test Analysis, 1987).

According to the Test Analysis (1987), the multiple choice sections "are intended to be relatively easy for the group as a whole, because differentiation among examinees is most useful in the lower range of the proficiency scale" (p. 6). Frequency distributions given in the Test Analysis for a representation of examinees taking the exam for the first time October 24, 1987, are negatively skewed indicating that "these statistics are in the desired range for a test designed to differentiate among examinees with skills in the lower range of the proficiency continuum" (p. 6).

The Test Analysis (1987) also indicated that speededness was not a factor for the group of examinees

tested. All of the group reached three-fourths of the items and 98% were able to reach the last item.

Items on the Mathematics Test were tested using the Mantel-Haenszel Differential Item Functioning Index (DIF) to determine whether they were more difficult for one subgroup than for another. Of the 40 items tested from the October, 1987, administration, 4 were categorized as having a relatively high DIF, 10 were in the middle range, and 26 were in the low range. Those in the mid to high range were required to be reviewed by a test specialist panel. The panel was to give rationale for each scoring decision for those in the high range (Test Analysis, 1988).

According to Oppenheim (1985), "responsibility for validity considerations is placed almost completely on the user" (p. 1187). No data are supplied to support the validity of the exam in the PPST Bulletin or in a user manual. Quellmalz (1985) states that "the appropriateness of the PPST for its proposed uses remains to be demonstrated" (p. 1189).

Results

Data Analysis

Data for this study were analyzed using the Statistical Package for the Social Sciences (SPSS).

Mathematics scores on the PPST were compared to ACT Mathematics, ACT English, ACT Social Studies, ACT Natural Science, and ACT Composite using Pearson Product correlations. Scores on the ACT are not required for transfer students at Harding, so these correlations were found only for the 76 students for whom ACT scores were available.

Scores in Mathematics on the PPST were compared to GPA at the time of the exam and Mathematics 115 semester grades using Spearman's rho. Mathematics 115 semester grades were available for 35 subjects who were primarily elementary majors who did not transfer math credits to Harding. This correlation was included because previous research indicated that elementary majors tended to have a lower pass rate than other students (Bethel et al., 1986; Nance & Kinnison, 1988) and Mathematics 115 is a course that the majority of Harding elementary majors take before taking the PPST.

Percentages passing the PPST Mathematics exam were calculated to compare males with females; elementary majors with other majors; and students born in or before 1965 with those born after 1965. The year 1965 was chosen to separate the younger students who went straight through school from those who took time out

from school. Chi-square (Pearson's and Fisher's Exact Test) was used to test the frequencies.

No comparisons were made by race because only one subject declared a race other than Caucasian.

The t-test was used to compare repeat PPST mathematics scores with previous scores.

Findings

The mean score on the Mathematics Test of the PPST for this sample ($N = 118$) was 175.84 and the standard deviation was 7.37. Findings are given below for each of the hypotheses.

1. There is no relationship between scores on the PPST Mathematics exam and the ACT Composite scores.

A correlation of .84 was found between PPST Mathematics scores and ACT Composite scores with $p < .001$.

2. There is no relationship between scores on the PPST Mathematics exam and ACT Mathematics scores.

The correlation between PPST Mathematics scores and ACT Mathematics scores was .80 ($p < .001$).

3. There is no relationship between scores on the PPST Mathematics exam and ACT English scores.

A correlation of .58 was found between PPST Mathematics scores and ACT English scores ($p < .001$).

4. There is no relationship between scores on the PPST Mathematics exam and ACT Social Studies scores.

A correlation of .64 was found between PPST Mathematics scores and ACT Social Studies scores ($p < .001$).

5. There is no relationship between scores on the PPST Mathematics exam and ACT Natural Science scores.

The correlation between PPST Mathematics and ACT Natural Science scores was .73 ($p < .001$).

6. There is no relationship between scores on the PPST Mathematics exam and the sex of those taking the exam.

In this study, 20% of the females failed the PPST Mathematics exam and 13% of the males failed. A Fisher's Exact Test showed that the difference was not significant ($p = .56$). (Fisher's was used because the expected value for one cell was too low for chi-square.)

7. There is no relationship between scores on the PPST Mathematics exam and the race of those taking the exam.

This relationship was not tested because only one of the 118 subjects declared a race other than Caucasian.

8. There is no relationship between scores on the PPST Mathematics exam and the major of those taking the exam.

Those declaring elementary education as their major had a failing rate of 30.4% while other majors had a failing rate of 11.1%. This difference had a Pearson chi-square value of 6.91 which was significant ($p < .01$).

9. There is no relationship between scores on the PPST Mathematics exam and GPA of those taking the exam.

The correlation between PPST Mathematics scores and GPA was .5262 ($p < .001$).

10. There is no relationship between scores on the PPST Mathematics exam and age of those taking the exam.

Those born after 1965 had a failing rate of 19.6% and those born before or in 1965 had a failing rate of 14.3%. A Fisher's Exact test showed that this difference was not significant ($p = .76$). (Again, Fisher's was used because of a low expected value in one cell.)

11. There is no relationship between scores on the PPST Mathematics exam and Mathematics 115 semester grades.

A correlation of .60 was found between PPST Mathematics scores and Mathematics 115 semester grades ($p < .001$).

12. There is no relationship between scores on the PPST Mathematics exam and prior scores on the exam.

In this group of subjects only seven had repeated the mathematics portion of the PPST between January 1, 1989, and October 1, 1989. Of these seven, only one passed and six failed the exam again. Three made the same score as before; one raised the score by one point; one, by three points; and two by four points. The average score for the first exam for the group of seven was 165.71. The average for the retake was 167.43. This difference was not significant at the .05 level (t-test).

A regression equation for predicting PPST Mathematics scores was found using the Stepwise Selection method. Variables considered were ACT Composite, ACT Mathematics, ACT English, ACT Natural Science, and ACT Social Studies.

Two variables, ACT Composite (ACT C) and ACT Mathematics (ACT M), which together accounted for 75.07% of the variance in the PPST Mathematics scores, were used in the equation which follows:

PPST Math = .9029 (ACT C) + .3706 (ACT M) + 151.7171. The standard error for the ACT composite coefficient was .1637; for the ACT Mathematics coefficient it was .1087; and for the constant it was 2.0606.

Summary and Conclusions

Summary

The PPST is an exam which all Arkansas education students must pass in order to be able to be admitted to teacher education programs. Between the months of January and October in 1989, 18.64% of Harding University students who took the PPST for the first time failed the Mathematics exam.

The purpose of this study was to investigate possible predictors of performance on the PPST Mathematics exam and to develop a regression equation for use at Harding.

Previous literature indicated that a relationship might exist between PPST Mathematics scores and ACT scores, race, major, GPA, age, and prior scores on the PPST Mathematics exam.

The following correlations were found: PPST Mathematics and ACT Composite, .84; PPST Mathematics and ACT Mathematics, .80; PPST Mathematics and ACT English, .58; PPST Mathematics and ACT Social Studies, .64; PPST Mathematics and ACT Natural Science, .73;

PPST Mathematics and GPA, .53; and PPST Mathematics and Math 115 semester grades, .60. All of these correlations were significant ($p < .001$).

No significant difference was found between pass-fail rates for age or sex. Race was not considered because only one subject reported a race other than Caucasian. A significant difference ($p < .01$) was found between pass-fail rates for those declaring elementary education as their major and those declaring other majors with 30.4% of elementary majors failing and 11.1% of other majors failing.

Of the seven subjects who retook the PPST Mathematics exam between January and October of 1989, six failed it again. The difference in the mean of the scores of the first exam and the mean of the scores on the retake was not significant.

The following regression equation was developed:

PPST Math = .9029 (ACT C) + .3076 (ACT M) + 151.7171.

Conclusions

The correlations between PPST Mathematics and the ACT subtests and the ACT Composite were all moderate to high. The highest two were ACT Mathematics (.80) and ACT Composite (.84) which together accounted for 75.07% of the variance in the PPST Mathematics scores.

The regression equation developed from these could be useful for predicting which Harding students might have problems with the PPST Mathematics exam.

This study did not support the use of age, sex, or race as predictors of success on the PPST Mathematics exam at Harding. Major was a significant factor, though. The elementary majors had a failing rate of 30.4% as opposed to a failing rate of 11.1% for other majors. Because previous research indicated that elementary majors might have more problems with the PPST Mathematics exam, the relationship between PPST Mathematics scores and Mathematics 115 grades was considered. A substantial correlation of .60 was found. This grade might be another factor to consider for elementary majors in prediction of success on the PPST Mathematics exam.

A moderate correlation of .53 was found between PPST Mathematics and GPA. This correlation is lower than the correlations for ACT Composite and ACT Mathematics; but for transfer students, GPA may be the only useful data available.

Although the size of the group of students who retook the PPST Mathematics exam during the time period of the study was small, findings indicate that special care should be taken with those who have

previously failed the Mathematics section. There was not a significant rise in the scores on the second try, and only 14.3% of the students passed on the second try.

Implications

A question that arose from these findings and from the review of previous research was whether the requirement of the PPST Mathematics exam should be lifted for those with high ACT Mathematics scores. A great deal of time and expense could be saved by such an exemption policy. Further research would help to determine the feasibility of this and what cut-off score might be appropriate.

Further research is also needed to find what is the best intervention program for those who are predicted to do poorly on the PPST Mathematics examination.

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